

The Claims

What is claimed is:

1. A trawl which during field operations in a water entrained environment becomes disposed symmetrically about a central axis, the trawl comprising:

5 a plurality of mesh cells, each mesh cell including at least three mesh bars, during field operations of the trawl in a water entrained environment at least a portion of at least one of said mesh bars of at least one of the mesh cells exhibiting a hydrofoil-like effect that aids in increasing a performance characteristic of a trawl system, that portion of mesh bars which
10 exhibit the hydrofoil-like effect being:

a. offset from the central axis of the trawl;

b. formed with a hydrofoil shape that:

i. has a lay with a loose, corkscrew-shaped pitch establishing a groove; and
15 ii. is oriented to establish leading and trailing edges for that portion of mesh bars which exhibit the hydrofoil-like effect, both:

(1) the lay of that portion of mesh bars which exhibit the hydrofoil-like effect having an orientation relative to a receding direction; and
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(2) the leading edge of that portion of mesh bars which exhibit the hydrofoil-like effect, when normalized to the receding direction relative to said central axis, residing at a side of said mesh bar, that are selected from a group consisting of:
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(a) a left-hand lay, and the leading edge being a right side of said mesh bar as viewed in the receding direction; and
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(b) a right-hand lay, and the leading edge being a left side of said mesh bar as viewed in the receding direction;

so that movement of the mesh bar through the water entrained environment relative to a water flow vector creates a pressure differential across that portion of mesh bars which
35 exhibit the hydrofoil-like effect thereby establishing a

lift vector relative to the central axis of the trawl, the water flow vector being neither parallel nor perpendicular to the mesh bar;

40 c. the mesh bar intersecting with at least one other mesh bar; and

d. that portion of mesh bars which exhibit the hydrofoil-like effect being formed from a material that has a substantially incompressible cross-sectional shape;

45 whereby the lift vector created by movement of the mesh bars which have a portion that exhibits the hydrofoil-like effect through the water entrained environment during field operations increases the performance characteristic of the trawl which is selected from a group consisting of increased trawl volume,
50 improved trawl shape, reduced vibration, reduced noise, and reduced drag.

2. The trawl of claim 1 having a forward section wherein mesh bars made of product strands include a series of at least thirty-five (35) cambered sections.

3. The trawl of claim 1 having a forward section wherein mesh bars made of straps include a series of at least twenty-five (25) cambered sections.

4. The trawl of claim 1 wherein for that portion of mesh bars which exhibit the hydrofoil-like effect a recess formed between outer surfaces of principal, larger diameter product strands is occupied by auxiliary, smaller diameter product
5 strands.

5. The trawl of claim 4 wherein that portion of mesh bars which exhibit the hydrofoil-like effect is enclosed within a sheath.

6. The trawl of claim 1 wherein a principal and an intermediate product strands together with auxiliary product strands forming that portion of mesh bars which exhibit the hydrofoil-like effect are coated with a bonding material.

7. The trawl of claim 1 wherein a principal and an intermediate product strands together with auxiliary product strands forming that portion of mesh bars which exhibit the hydrofoil-like effect are arranged to have a cross-sectional shape approximating that of a strap.

8. The trawl of claim 1 wherein straps forming portion of mesh bars which exhibit the hydrofoil-like effect have a parallelogram cross-sectional shape.

9. The trawl of claim 8 wherein the parallelogram-shaped straps have a pointed leading edge.

10. The trawl of claim 8 wherein the parallelogram-shaped mesh bar is formed by a principal product strand and a pair of intermediate product strands juxtaposed with diametrically opposite sides of the principal product strand.

11. The trawl of claim 8 wherein the parallelogram-shaped mesh bar is formed by a product strand that is enclosed within a sheath that is gathered along at least one side of the product strand to form an outwardly projecting ridge.

12. The trawl of claim 1 wherein straps forming portion of mesh bars which exhibit the hydrofoil-like effect have a hexagonal cross-sectional shape.

13. The trawl of claim 1 wherein straps forming portion of mesh bars which exhibit the hydrofoil-like effect have a triangular cross-sectional shape.

14. The trawl of claim 1 wherein portions of mesh bars which exhibit the hydrofoil-like effect made of straps having a drooping leading edge and a raised trailing edge.

15. The trawl of claim 1 wherein portions of mesh bars which exhibit the hydrofoil-like effect made of straps include angled shaping strips that project from side surfaces of the straps.

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16. The trawl of claim 1 wherein the loose, corkscrew-shaped pitch for that portion of mesh bars which exhibit the hydrofoil-like effect that consist of a pair of product strands is in a range of 3d to 70d, where d is a diameter
5 of a smaller product strand of the pair.

17. The trawl of claim 16 wherein the loose, corkscrew-shaped pitch is the range of 5d to 55d.

18. The trawl of claim 16 wherein the loose, corkscrew-shaped pitch is the range of 5d to 15d for maximum lift.

19. The trawl of claim 16 wherein the loose, corkscrew-shaped pitch is the range of 25d to 55d for minimum drag.

20. The trawl of claim 1 wherein the loose, corkscrew-shaped pitch for that portion of mesh bars which exhibit the hydrofoil-like effect that are formed by more than a pair of product strands having differing diameters is in a range
5 of 3d to 70d, where d is a diameter of a next-to-largest product strand.

21. The trawl of claim 20 wherein the loose, corkscrew-shaped pitch is the range of 5d to 55d.

22. The trawl of claim 20 wherein the loose, corkscrew-shaped pitch is the range of 5d to 15d for maximum lift.

23. The trawl of claim 20 wherein the loose, corkscrew-shaped pitch is the range of 25d to 55d for minimum drag.

24. The trawl of claim 1 wherein the loose, corkscrew-shaped pitch for that portion of mesh bars which

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exhibit the hydrofoil-like effect that are formed by a strap is in a range of $3d$ to $70d$, where d is a width of the strap.

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25. The trawl of claim 24 wherein the loose, corkscrew-shaped pitch is the range of $8d$ to $30d$ for maximum lift.

26. The trawl of claim 24 wherein the loose, corkscrew-shaped pitch is the range of $9d$ to $21d$ for minimum drag.

27. The trawl of claim 1 wherein portions of mesh bars which exhibit the hydrofoil-like effect made of straps have a ratio of a width of the strap to a thickness of the strap in a range of $1.5:1$ to $20:1$.

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28. The trawl of claim 27 wherein the ratio is in the range $2.75:1$ to $10.0:1$ that provides high lift.

29. The trawl of claim 27 wherein the ratio is in the range $1.8:1$ to $2.5:1$ which provides low drag with good lift.

30. The trawl of claim 27 wherein the ratio is in the range $1.5:1$ to $1.8:1$ that provides lower drag.

31. The trawl of claim 1 wherein the trawl is in a mid-water trawl.

32. A trawl which during field operations in a water entrained environment becomes disposed symmetrically about a central axis, the trawl comprising:

a plurality of mesh cells, each mesh cell including at least three mesh bars, during field operations of the trawl in a water entrained environment at least a portion of at least one of said mesh bars of at least one of the mesh cells exhibiting a hydrofoil-like effect that aids in increasing a performance characteristic of a trawl system, that portion of mesh bars which exhibit the hydrofoil-like effect being:

10 a. offset from the central axis of the trawl;

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- b. formed with a hydrofoil shape that:
- i. has a lay with a loose, corkscrew-shaped pitch establishing a groove; and
 - ii. is oriented to establish leading and trailing edges for that portion of mesh bars which exhibit the hydrofoil-like effect, both:
 - (1) the lay of that portion of mesh bars which exhibit the hydrofoil-like effect having an orientation relative to a receding direction; and
 - (2) the leading edge of that portion of mesh bars which exhibit the hydrofoil-like effect, when normalized to the receding direction relative to said central axis, residing at a side of said mesh bar, that are selected from a group consisting of:
 - (a) a left-hand lay, and the leading edge being a right side of said mesh bar as viewed in the receding direction; and
 - (b) a right-hand lay, and the leading edge being a left side of said mesh bar as viewed in the receding direction;
- so that movement of the mesh bar through the water entrained environment relative to a water flow vector creates a pressure differential across that portion of mesh bars which exhibit the hydrofoil-like effect thereby establishing a lift vector relative to the central axis of the trawl, the water flow vector being neither parallel nor perpendicular to the mesh bar;
- c. the mesh bar intersecting with at least one other mesh bar; and
 - d. that portion of mesh bars which exhibit the hydrofoil-like effect being formed from a bonded material;
- whereby the lift vector created by movement of the mesh bars which have a portion that exhibits the hydrofoil-like effect through the water entrained environment during field operations increases the performance characteristic of the trawl which is selected from a group consisting of increased trawl volume, improved trawl shape, reduced vibration, reduced noise, and reduced drag.

33. A trawl which during field operations in a water entrained environment becomes disposed symmetrically about a central axis, the trawl comprising:

- 5 a plurality of mesh cells, each mesh cell including at least three mesh bars, during field operations of the trawl in a water entrained environment at least a portion of at least one of said mesh bars of at least one of the mesh cells exhibiting a hydrofoil-like effect that aids in increasing a performance characteristic of a trawl system, that portion of mesh bars which
- 10 exhibit the hydrofoil-like effect being:
- a. offset from the central axis of the trawl;
 - b. formed by a strap having a parallelogram cross-sectional shape so that movement of the mesh bar through the water entrained environment relative to a water
 - 15 flow vector creates a pressure differential across that portion of mesh bars which exhibit the hydrofoil-like effect thereby establishing a lift vector relative to the central axis of the trawl, the water flow vector being neither parallel nor perpendicular to the mesh bar; and
 - 20 c. the mesh bar intersecting with at least one other mesh bar;

whereby the lift vector created by movement of the mesh bars which have a portion that exhibits the hydrofoil-like effect through the water entrained environment during field operations

25 increases the performance characteristic of the trawl which is selected from a group consisting of increased trawl volume, improved trawl shape, reduced vibration, reduced noise, and reduced drag.

34. The trawl of claim 34 wherein the parallelogram cross-sectional shaped strap is formed by laminating a plurality of rectangularly shaped straps.

35. The trawl of claim 35 wherein that portion of mesh bars which exhibit the hydrofoil-like effect being formed from bonded material.

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36. A trawl which during field operations in a water entrained environment becomes disposed symmetrically about a central axis, the trawl comprising:

5 a plurality of mesh cells, each mesh cell including at least three mesh bars, a first and a second of said mesh bars of at least one of the mesh cells being formed by straps and having at least one flexible interconnecting connection therebetween which includes shackles that are joined respectively to the first and second of said mesh bars and are also mechanically joined together, during field operations of the trawl in a water entrained environment at least a portion both of the first and of the second of said mesh bars exhibiting a hydrofoil-like effect that aids in increasing a performance characteristic of a trawl system, that portion of mesh bars which exhibit the hydrofoil-like effect being:

- 15 a. offset from the central axis of the trawl; and
b. formed with a hydrofoil shape that:
- 20 i. has a lay with a loose, corkscrew-shaped pitch establishing a groove; and
ii. is oriented to establish leading and trailing edges for that portion of mesh bars which exhibit the hydrofoil-like effect, both:

- (1) the lay of that portion of mesh bars which exhibit the hydrofoil-like effect having an orientation relative to a receding direction; and
25 (2) the leading edge of that portion of mesh bars which exhibit the hydrofoil-like effect, when normalized to the receding direction relative to said central axis, residing at a side of said mesh bar, that are selected from a group consisting of:

- 30 (a) a left-hand lay, and the leading edge being a right side of said mesh bar as viewed in the receding direction; and
(b) a right-hand lay, and the leading edge being a left side of said mesh bar as viewed
35 in the receding direction;

so that movement of the mesh bar through the water entrained environment relative to a water flow vector creates a

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40 pressure differential across that portion of mesh bars which
 exhibit the hydrofoil-like effect thereby establishing a
 lift vector relative to the central axis of the trawl, the
 water flow vector being neither parallel nor perpendicular
 to the mesh bar;
 whereby the lift vector created by movement of the mesh bars
45 which have a portion that exhibits the hydrofoil-like effect
 through the water entrained environment during field operations
 increases the performance characteristic of the trawl which is
 selected from a group consisting of increased trawl volume,
 improved trawl shape, reduced vibration, reduced noise, and
50 reduced drag.

37. The trawl of claim 37 wherein that portion of mesh bars
which exhibit the hydrofoil-like effect being formed from bonded
material.

38. A trawl which during field operations in a water
entrained environment becomes disposed symmetrically about a
central axis, the trawl comprising:

- 5 a plurality of mesh cells, each mesh cell including at least
 three mesh bars, a first and a second of said mesh bars of at
 least one of the mesh cells being formed by straps and having at
 least one interconnecting connection therebetween fixed by
 laminating together short sections of straps forming the first
 and the second of said mesh bars, during field operations of the
 trawl in a water entrained environment at least a portion both of
10 the first and of the second of said mesh bars exhibiting a
 hydrofoil-like effect that aids in increasing a performance
 characteristic of a trawl system, that portion of mesh bars which
 exhibit the hydrofoil-like effect being:
- 15 a. offset from the central axis of the trawl; and
 - b. formed with a hydrofoil shape that:
 - 1. has a lay with a loose, corkscrew-shaped pitch
 establishing a groove; and
 - 20 ii. is oriented to establish leading and trailing
 edges for that portion of mesh bars which exhibit the
 hydrofoil-like effect, both:

(1) the lay of that portion of mesh bars which exhibit the hydrofoil-like effect having an orientation relative to a receding direction; and
(2) the leading edge of that portion of mesh bars which exhibit the hydrofoil-like effect, when normalized to the receding direction relative to said central axis, residing at a side of said mesh bar, that are selected from a group consisting of:

(a) a left-hand lay, and the leading edge being a right side of said mesh bar as viewed in the receding direction; and

(b) a right-hand lay, and the leading edge being a left side of said mesh bar as viewed in the receding direction;

so that movement of the mesh bar through the water entrained environment relative to a water flow vector creates a pressure differential across that portion of mesh bars which exhibit the hydrofoil-like effect thereby establishing a lift vector relative to the central axis of the trawl, the water flow vector being neither parallel nor perpendicular to the mesh bar;

whereby the lift vector created by movement of the mesh bars which have a portion that exhibits the hydrofoil-like effect through the water entrained environment during field operations increases the performance characteristic of the trawl which is selected from a group consisting of increased trawl volume, improved trawl shape, reduced vibration, reduced noise, and reduced drag.

39. The trawl of claim 39 wherein that portion of mesh bars which exhibit the hydrofoil-like effect being formed from bonded material.